2018 updated South Coast Rock Lobster assessment results

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Summary

The 2017 assessment of the resource for South Coast rock lobster is updated given the two further years of catch-at-length data and one further year of CPUE data now available. Recruitment is estimated to have decreased over the last two seasons for which this is now estimable (2007 and 2008). The spawning biomass trajectory decreases slightly over recent years. Current spawning biomass is estimated to be 29% of *K*. The Reference Case (RC) MSY estimate is 358 MT at a B_{sp}/K of 0.29. F_{msy} is estimated to be 0.29, though MSY-related estimates are heavily dependent on assumptions made about the stock-recruitment relationship. The RC model estimates that the resource is currently at B_{msy}.

Introduction

The most recent South Coast rock lobster assessment that was previously reported was that conducted in 2017 (Johnston and Butterworth 2017). This document reports an update to that assessment, where this 2018 update includes fitting to the following data.

1. GLM standardised CPUE data for each area (A1E, A1W, and A2+3): 1977-2016, i.e. one further year of data.
2. Catch-at-length (CAL) data (males and females separately) for each area: 1995-2015 (the 2017 assessment included data to 2013 only).
3. Catch data for each area (1973-2016). For 2017 and 2018 the catches are assumed to be equal to the TAC values, and the areal proportional splits of these two catches are the average of the 2015 and 2016 reported catches for each area (A1E=0.117, A1W=0.531 and A2+3 = 0.352).

Stock recruit residuals are now estimated for the 1974-2008 period.

Previous assessment models have fixes the "λ^A" values for each of the three areas. These λ^A (which sum to 1.0) split the total recruitment for the resource amongst the three areas. Previously, assessments had not been able to estimate sensible values for these parameters and they were fixed to a set of previously estimated values. The New Reference Case (RC) model reported here moves from this "fixing" of the λ^A parameters, and instead estimates them in the model fitting process. For this model, noise is added to the λ^A terms only from 1974 (not for 1973).

Note that for the RC model, the CPUE and CAL data receive **equal** weighting and the 1999 and 2006 CAL data are removed from the likelihood because of very small sample sizes. Three sensitivities are run (as for the 2017 assessment).

- Sen1: CAL data down-weighted by a factor of 0.5.
- Sen2: CAL data down-weighted by a factor of 0.1.
- Sen3: The stock-recruit log-residual standard deviation σ_R is reduced from the RC value of 0.8 to 0.4.

The model had problems estimating the λ^A values for Sen1 and Sen2 (the recruitment was forced nearly entirely into A1E, so that for these two sensitivities these values were fixed at the best fit values obtained for the RC.

Note that at the November 2017 International Stock Assessment Workshop held at UCT, the international Panel recommended that the CAL data should receive equal weight to the CPUE data, and that time-varying selectivity apply only for area A2+3.

Calculation of MSY and Bmsy

MSY and B_{msy} values are now reported. The fact that the steepness h is either equal or nearly equal to 1 for the RC assessment and the sensitivities considered (see Table 2) renders MSY estimation problematic, as such steepness indicates virtually no drop in recruitment as spawning biomass (B^{sp}) falls. Hence, for more realistic results, the assumption has been made that below a certain B^{sp} value, recruitment falls proportional to B^{sp}. More specifically, if R_0 is the value of recruitment when B^{sp}/K^{sp}=0.287, then for lower values of B^{sp}/K^{sp}:

$$R = R_0(B^{sp}/K^{sp})/0.287 \tag{1}$$

The value of 0.287 is the lowest for the B^{sp}/K^{sp} trajectory for the NEW RC assessment.

MSY itself is then computed by projecting the population 150 years into the future under a constant fishing proportion for values ranging from 0 to 1.0, and finally the value of F at what maximum catch is obtained (after transients have disappeared) is taken to be F_{msy}.

For each F value, the annual catch is calculated as follows:

$$C_y = FB_y^{exp} \tag{2}$$

Should a situation occur at a given F where the catch proportion in one area is above 0.95 (usually for A1E and A1W at high F values) then catch for that area is added to the catch from A2+3, and no catch is assumed to be taken from the depleted area.

Some further assumptions need to be made for these projections as set out below.

Future recruitment:

$$R_y = \frac{\alpha B_y^{sp}}{\beta + (B_y^{sp})^{\gamma}} e^{\varsigma_y} \tag{3}$$

where e^{ς_y} is set to $e^{0.8^2/2}$ to give the average value for recruitment, given the RC assumption that σ_R=0.8.

Future proportional splits of recruitment between the three areas: (λ^A)

The baseline λ^A values are set at the RC point estimates:

λ^{A1E} =0.15

λ^{A1W}=0.17

λ^{A2+3}=0.68

Future catch split by area:

The ratios of the average *F* (fishing proportion) over the 2013-2017 period for each area are used.

Future selectivity:

For A1E and A1W where selectivity is not time varying, these selectivities are assumed to apply in the future. For A2+3 where time variance is allowed in the fitting process for years where data are available (1995-2015), the baseline selectivity function (for 1973-1994) is used (see Figure 4a).

Results of updated assessments

The assessment is essentially identical to that in 2017, except for the addition of new catch-at-length, CPUE and catch data.

Table 1 reports the results of the 2018 updated 2018 NEW RC assessment (with the corresponding 2017 RC assessment results provided in the first column for comparative purposes) and fixing of the λ^A (at those estimated in 2016). Table 1 also reports the results of the NEW RC 2018 where the λ^A values are estimated.

Table 2 reports results of the NEW RC and three sensitivity tests, where the catch-at-length data are down-weighted in the fitting procedure, and where the stock-recruitment log-residual standard deviation σ_R is reduced.

Figure 1a compares the 2017 and 2018 NEW RC model fits to the CPUE. Figure 1b compares the 2018 NEW RC, Sen1 and Sen2 assessments, which shows how down-weighting the CAL data affects the fit to CPUE.

Figure 1c compares the 2017 and 2018 NEW RC estimated spawning biomass relative to pristine (B_y^{sp}/K), whilst Figure 1d compares these trajectories for the 2018 NEW RC, Sen1 and Sen2. Figure 1e compares the estimated series of stock-recruit residuals between the 2017 and the NEW RC 2018 assessments. Figure 1f shows the 2018 NEW RC estimated proportional splits of recruitment to each area.

Figure 2 shows plots of the exploitable biomass relative to K for the NEW RC 2018 assessment, whilst Figure 3 shows NEW RC model estimates of *F* (the harvest proportion).

Figure 4a shows the 2018 RC estimated selectivity functions for each area. Note that the A2+3 selectivity functions vary over time for the period 1995-2015; these are shown in Figure 4b.

Figure 4c compares the stock recruit residuals for the NEW RC (**σ_R=0.8)** and for Sen3 **(σ_R=4).**

Figure 5 shows the catch at length residuals for the 2018 NEW RC.

Figure 6 shows the sustainable yield (SY) curve estimated for the NEW RC, as well the SY against *F* curve, whilst Table 2 provides a summary of the MSY and related estiamtes for the different models.

Discussion

Comparison between the 2017 and 2018 assessment

The updated NEW RC assessment produces slightly more pessimistic results than those from the 2017 assessment. In 2017 the spawning biomass in 2016 relative to pristine was estimated to be 0.32, whereas the 2018 updated assessment estimates this to be somewhat lower at 0.29, with current (2019) spawning biomass relative to *K* at 0.29 (see Table 1). The spawning biomass relative to *K* is reasonably stable over recent years, though also decreasing slightly for this updated 2018 assessment (Figure 1c). Note also that the stock recruit residuals for the 2004-2006 period (Figure 1e) are much lower for the 2018 assessment compared to the 2017 assessment, but increase back up to the higher levels for 2007 and 2008 as seen in the 2017 assessment.

Sensitivity to down-weighting the CAL data

Previous assessments have shown that down-weighting the CAL data produces different results from the RC (which gives equal weight to both the CPUE and CAL data). This feature remains evident in the updated 2018 assessments but the differences are ameliorated somewhat. Down-weighting the CAL data produces slightly more optimistic results. As the catch-at-length (CAL) data are down-weighted, as might be expected the fits to the CPUE improve (see the –lnL CPUE values in Table 2 and Figure 2a) and the fits to the CAL data deteriorate (see –lnL SCI CAL values in Table 2). For the 0.1 downweighting, from 1985 onwards the CPUE are almost exactly fitted by the model, pointing towards overparametrisation and unreliable results. Figure 1d compares the exploitable biomass trends for the RC and the two CAL downweighted sensitivities, and shows that the exploitable biomass trends are similar for the RC and Sen 1), but Sen 2, for which the CAL data are downweighted by a factor of 0.1, the recent biomass trajectory is far more optimistic.

Changing the σ_R value from 0.8 to 0.4

The RC model assumes a stock recruitment log-residual standard deviation (σ_R) value of 0.80. This is quite a high value, but past analyses have consistently shown much better fits to the data with this value of σ_R . The sensitivity (Sen 3) using a lower σ_R value 0.4 produces inferior fits to both the CPUE and CAL data (see Table 2).

MSY estimates

The MSY, B_{msy}^{sp} and F_{msy} values have been estimated for the RC and sensitivity tests. Table 3 summarises these and the current B_{sp}(2019) estimates. Figure 6 shows graphical plots for the RC of SY against B_{sp} (top) indicating MSY, B_{msy} and the current spawning biomass. The lower plot shows the RC estimated F against B_{msy}. The RC model estimates the current population to be virtually at the B_{msy} value. Sen 2 estimates current spawning biomass to be somewhat above the B_{msy} estimates, whilst Sen 1 and Sen 3 estimate it to be below B_{msy} . It should be noted though that these MSY-related estimates depend heavily on the assumption made in equation (1) concerning the stock-recruitment relationship.

Reference

Johnston, S.J. and Butterworth, D.S. 2017. 2017 updated south coast rock lobster assessment results. FISHERIES/2017/AUG/SWG-SCRL/06.

Table 1: Estimated model parameters and –*ln*L values for the updated 2018 RC and "New RC" models are given in the second and third columns. The results for the 2017 assessment are reported in the first column for comparison. Values in parenthesis alongside the –lnL values are σ values. Likelihoods from the 2017 model are not comparable with those for the two 2018 models due to differing data series.

	2017 RC CAL data received equal weight to CPUE Lambdas fixed	**2018 RC** CAL data received equal weight to CPUE Lambdas fixed	**2018 New RC** CAL data received equal weight to CPUE Lambdas estimated
	Scl17.tpl/rep	Om18fix.tpl	Om18.tpl
# parameters	250	260	263
-lnL Total	**-487.17**	**-603.77**	**-603.77**
-lnl CPUE	**-120.23**	**-22.84**	**-22.84**
-lnl CPUE A1E	-24.21 (0.33)	-259 (0.32)	-259 (0.32)
-lnl CPUE A1W	-54.92 (0.15)	-47.62 (0.18)	-47.62 (0.18)
-lnl CPUE A2+3	-41.09 (0.21)	-49.65 (0.17)	-49.65 (0.17)
-ln SCI CAL	**-421.95**	**-570.75**	**-570.75**
-ln SCI CAL A1E	-14.61 (0.14)	14.13 (0.15)	14.13 (0.15)
-ln SCI CAL A1W	-156.93 (0.08)	-152.97 (0.08)	-152.97 (0.08)
-ln SCI CAL A2+3	-250.41 (0.06)	-431.92 (0.04)	-431.92 (0.04)
K	4353	3237	3237
λ^{A1E}	0.15 (fixed)	0.15 (fixed)	0.15 estimated
λ^{A1W}	0.26 (fixed)	0.17 (fixed)	0.17 estimated
λ^{A2+3}	0.59 (fixed)	0.68 (fixed)	0.68 estimated
$B_{sp}(2015)$ $(B_{sp}(2015)/K_{sp})$	1386 (0.32)	972 (0.30)	972 (0.30)
$B_{sp}(2016)$ $(B_{sp}(2016)/K_{sp})$	1404 (0.32)	944 (0.29)	944 (0.29)
$B_{sp}(2017)$ $(B_{sp}(2017)/K_{sp})$	-	935 (0.29)	935 (0.29)
$B_{sp}(2018)$ $(B_{sp}(2018)/K_{sp})$	-	930 (0.29)	930 (0.29)
$B_{sp}(2019)$ $(B_{sp}(2019)/K_{sp})$	-	945 (0.29)	945 (0.29)
$B_{exp}(2015)$ $(B_{exp}(2015)/K_{exp})$ A1E	131 (0.49)	236 (0.52)	236 (0.52)
$B_{exp}(2015)$ $(B_{exp}(2015)/K_{exp})$ A1W	281 (0.36)	452 (0.31)	452 (0.31)
$B_{exp}(2015)$ $(B_{exp}(2015)/K_{exp})$ A2+3	851 (0.32)	2354 (0.43)	2354 (0.43)
$B_{exp}(2017)$ $(B_{exp}(2017)/K_{exp})$ A1E	-	213 (0.47)	213 (0.47)
$B_{exp}(2017)$ $(B_{exp}(2017)/K_{exp})$ A1W	-	252 (0.17)	252 (0.17)
$B_{exp}(2017)$ $(B_{exp}(2017)/K_{exp})$ A2+3	-	1845 (0.34)	1845 (0.34)
$B_{exp}(2018)$ $(B_{exp}(2018)/K_{exp})$ A1E	-	199 (0.44)	199 (0.44)
$B_{exp}(2018)$ $(B_{exp}(2018)/K_{exp})$ A1W	-	168 (0.12)	168 (0.12)
$B_{exp}(2018)$ $(B_{exp}(2018)/K_{exp})$ A2+3	-	1976 (0.36)	1976 (0.36)

Table 2: Estimated model parameters and –*ln*L values for the updated 2018 RC "New RC" model are given in the first column. The results of the three sensitivity analyses are reported in the following columns. Values in parenthesis are σ values. The –lnL CAL data values reported in these tables are those before any downweighting (if required) is applied to those values.

	2018 New RC **CAL data received equal weight to CPUE**	**2018 Sen1** **CAL data down-weighted by factor of 0.5**	**2018 Sen2** **CAL data down-weighted by factor of 0.1**	**2018 Sen3** **σ_R=0.4**
	Om18.tpl	Om18s1.tp	Om18s2.tpl	Om18s3.tpl
# parameters	263	260	260	260
-lnL Total	**-603.77**	**-334.89**	**-185.69**	**-587.22**
-lnl CPUE	**-122.84**	**-134.76**	**-188.57**	**-119.12**
-lnl CPUE A1E	-25.58 (0.32)	-26.07 (0.31)	-24.28 (0.33)	-24.94 (0.33)
-lnl CPUE A1W	-47.62 (0.18)	-53.52 (0.16)	-65.83 (0.12)	-48.20 (0.18)
-lnl CPUE A2+3	-49.65 (0.17)	-55.17 (0.15)	-98.45 (0.05)	-45.98 (0.19)
-ln SCI CAL	**-570.75**	**-493.18**	**-104.94**	**-566.98**
-ln SCI CAL A1E	14.13 (0.15)	19.14 (0.16)	25.67 (0.16)	16.01 (0.15)
-ln SCI CAL A1W	-152.97 (0.08)	-137.88 (0.08)	-53.11 (0.11)	-145.81 (0.08)
-ln SCI CAL A2+3	-431.92 (0.04)	-334.44 (0.05)	-77.50 (0.10)	-437.18 (0.04)
K	3237	3220	3957	3358
h	0.999	0.947	0.999	0.937
λ^{A1E}	0.15 estimated	0.15 fixed	0.15 fixed	0.15 fixed
λ^{A1W}	0.17 estimated	0.17 fixed	0.17 fixed	0.17 fixed
λ^{A2+3}	0.69 estimated	0.68 fixed	0.68 fixed	0.68 fixed
$B_{sp}(2015)$ ($B_{sp}(2015)/K_{sp}$)	972 (0.30)	970 (0.30)	1322 (0.33)	1085 (0.32)
$B_{sp}(2016)$ ($B_{sp}(2016)/K_{sp}$)	944 (0.29)	945 (0.29)	1348 (0.34)	1083 (0.32)
$B_{sp}(2017)$ ($B_{sp}(2017)/K_{sp}$)	935 (0.29)	937 (0.29)	1379 (0.35)	1107 (0.33)
$B_{sp}(2018)$ ($B_{sp}(2018)/K_{sp}$)	930 (0.29)	933 (0.29)	1400 (0.35)	1140 (0.34)
$B_{sp}(2019)$ ($B_{sp}(2019)/K_{sp}$)	945 (0.29)	948 (0.29)	1429 (0.36)	1193 (0.36)
$B_{exp}(2015)$ ($B_{exp}(2015)/K_{exp}$) A1E	236 (0.52)	245 (0.55)	175 (0.55)	243 (0.50)
$B_{exp}(2015)$ ($B_{exp}(2015)/K_{exp}$) A1W	452 (0.31)	421 (0.29)	243 (0.36)	501 (0.33)
$B_{exp}(2015)$ ($B_{exp}(2015)/K_{exp}$) A2+3	2354 (0.43)	2167 (0.40)	1616 (0.37)	2786 (0.50)
$B_{exp}(2017)$ ($B_{exp}(2017)/K_{exp}$) A1E	213 (0.47)	227 (0.51)	178 (0.56)	221 (0.47)
$B_{exp}(2017)$ ($B_{exp}(2017)/K_{exp}$) A1W	252 (0.17)	243 (0.17)	200 (0.30)	350 (0.23)
$B_{exp}(2017)$ ($B_{exp}(2017)/K_{exp}$) A2+3	1845 (0.34)	1817 (0.34)	1704 (0.39)	2250 (0.40)
$B_{exp}(2018)$ ($B_{exp}(2018)/K_{exp}$) A1E	199 (0.44)	214 (0.48)	179 (0.56)	214 (0.46)
$B_{exp}(2018)$ ($B_{exp}(2018)/K_{exp}$) A1W	168 (0.12)	171 (0.12)	179 (0.28)	294 (0.19)
$B_{exp}(2018)$ ($B_{exp}(2018)/K_{exp}$) A2+3	1976 (0.36)	1936 (0.36)	1785 (0.41)	2443 (0.44)

Table 3: MSY, Bmsy, *F*msy and current B_{sp}(2019) estimates for the 2018 RC and three sensitivity tests (units are MT for biomasses).

	RC	**Sen1** **CAL data down-weighted by factor of 0.5**	**Sen2** **CAL data down-weighted by factor of 0.1**	**Sen3** $\boldsymbol{\sigma_R}$**=0.4**
K	3237	3220	3957	3358
MSY	358	366	429	427
B_{msy}	931	1501	1291	1300
B_{msy}/K	0.288	0.466	0.326	0.387
$B_{sp}(2019)$	945	948	1429	1139
$B_{sp}(2019)/K$	0.292	0.294	0.361	0.339
$B_{sp}(2019)/B_{msy}$	1.015	0.632	1.107	0.876
F_{msy}	0.294	0.163	0.131	0.130
	Om18msy.tpl	Msys1.tpl	Msy2.tpl	Msy3.tpl

Figure 1a: Comparison of 2018 NEW RC fits to (standardised) CPUE data for each area, together with fits obtained from the 2017 RC assessment.

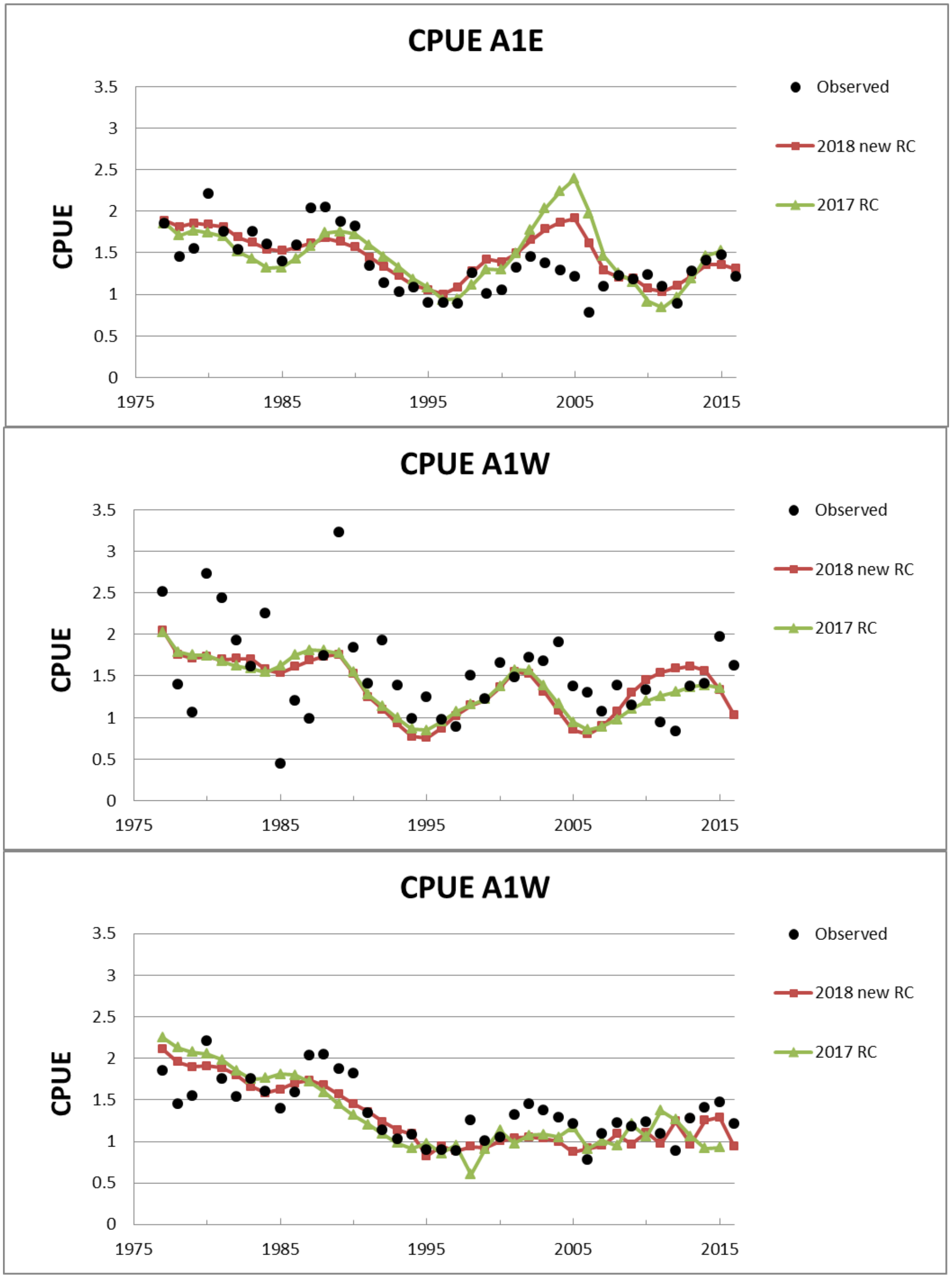


Figure 1b: Comparison of 2018 NEW RC fits to (standardised) CPUE data for each area, for the RC (CAL data given equal weight), Sen1 (CAL data down-weighted by a factor of 0.5) and Sen2 (CAL data down-weighted by a factor of 0.1).

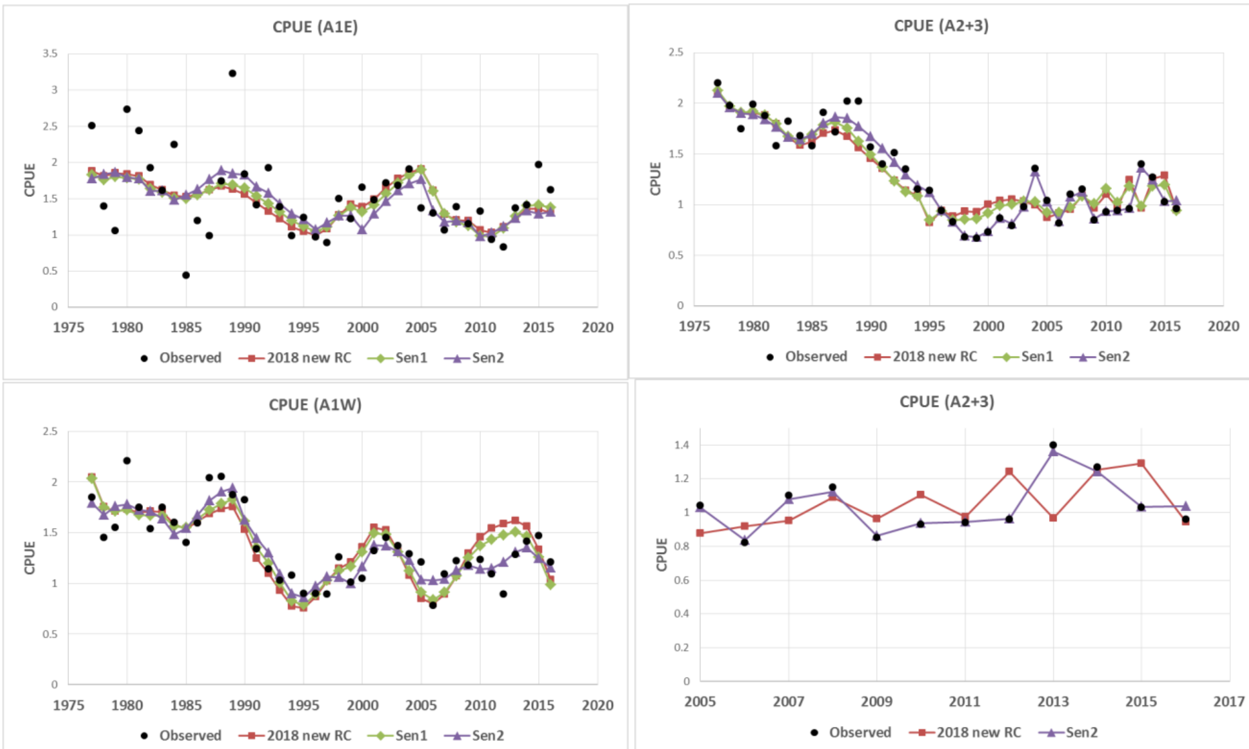


Figure 1c: Comparison of 2018 NEW RC estimated B_{sp}/K trajectory, with the trend obtained from the 2017 RC assessment.

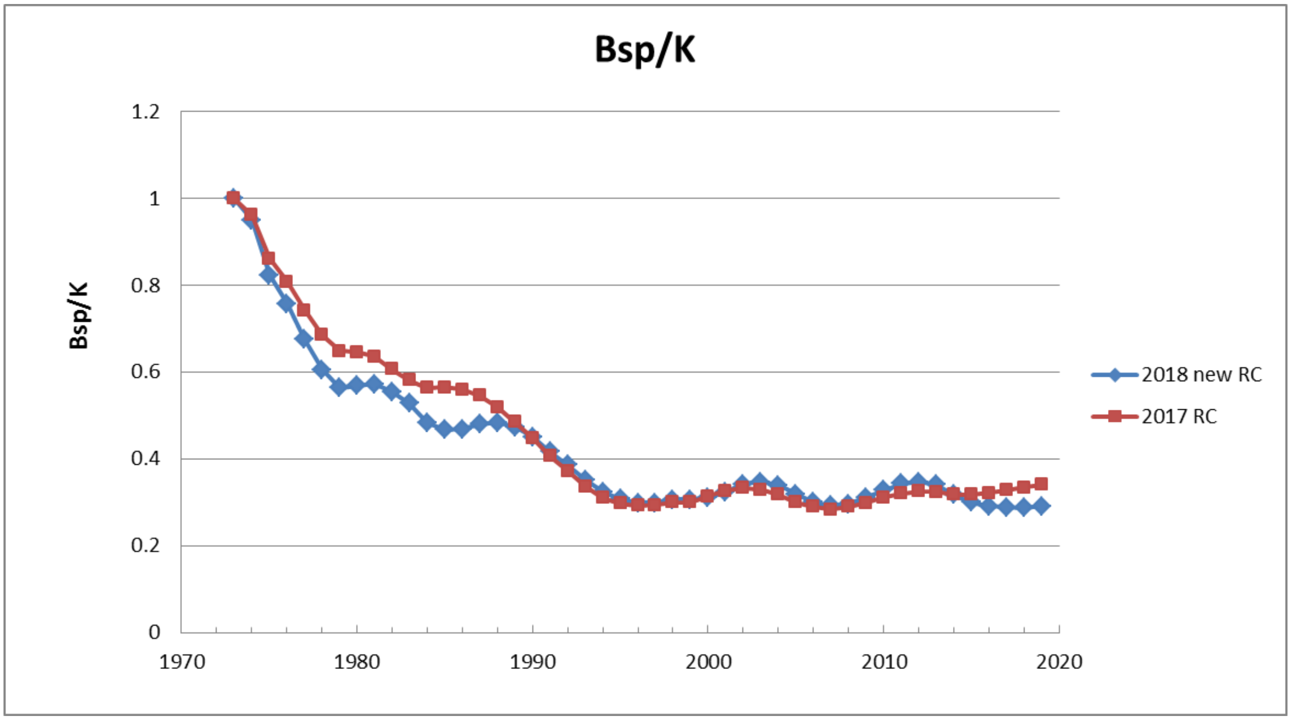


Figure 1d: Comparison of 2018 estimated Bsp/K trajectories for the RC (CAL data given equal weight), Sen1 (CAL data down-weighted by a factor of 0.5) and Sen2 (CAL data down-weighted by a factor of 0.1).

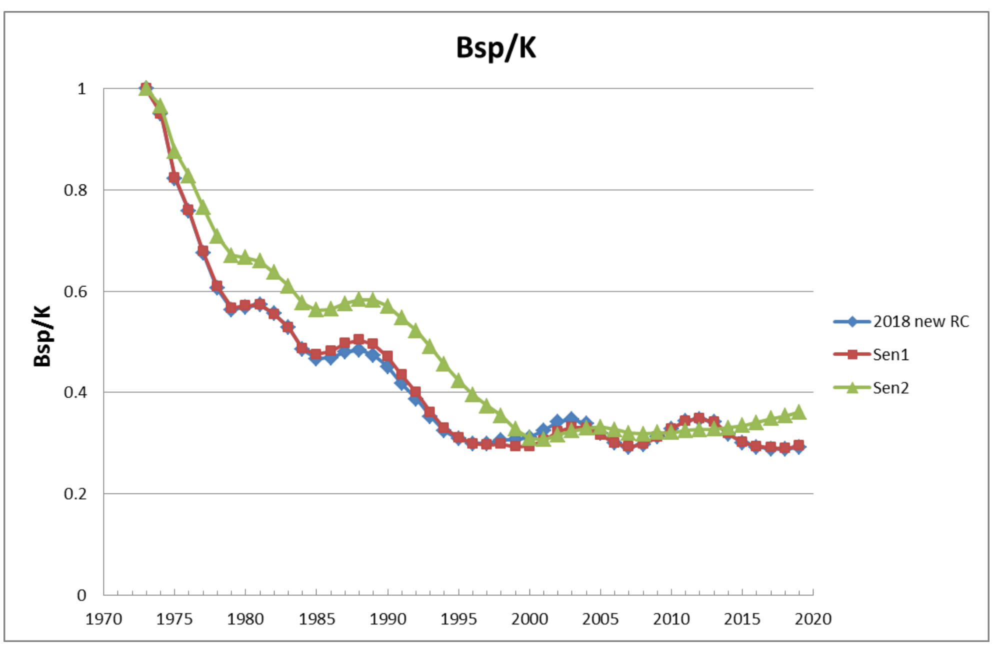


Figure 1e: Comparison of 2018 NEW RC stock-recruitment residuals with those obtained from the 2017 RC assessment.

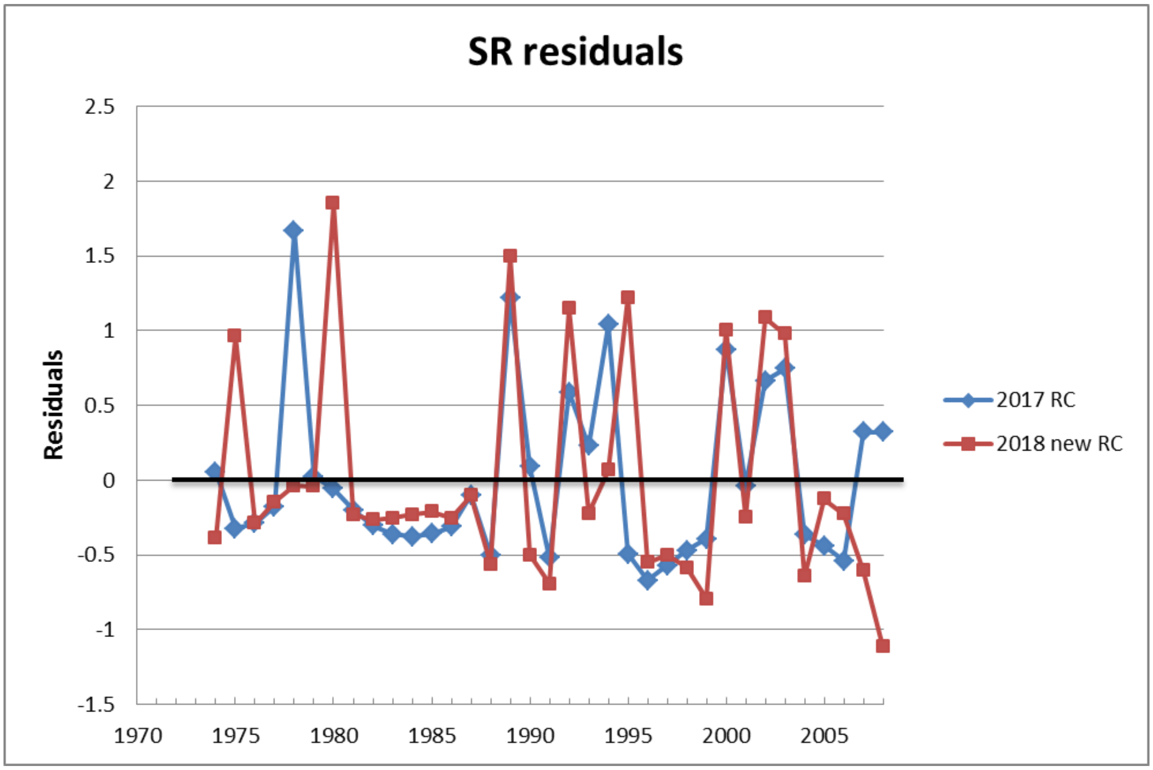


Figure 1f: The 2018 NEW RC proportional splits of recruitment to each area.

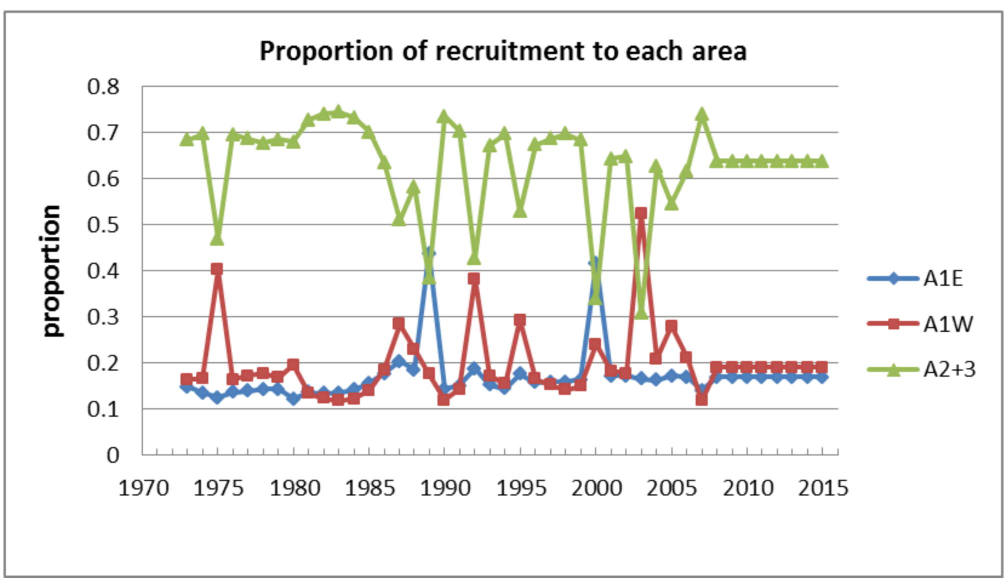


Figure 2: Model estimates of **exploitable biomass relative to *K*** for the 2018NEW RC assessment.

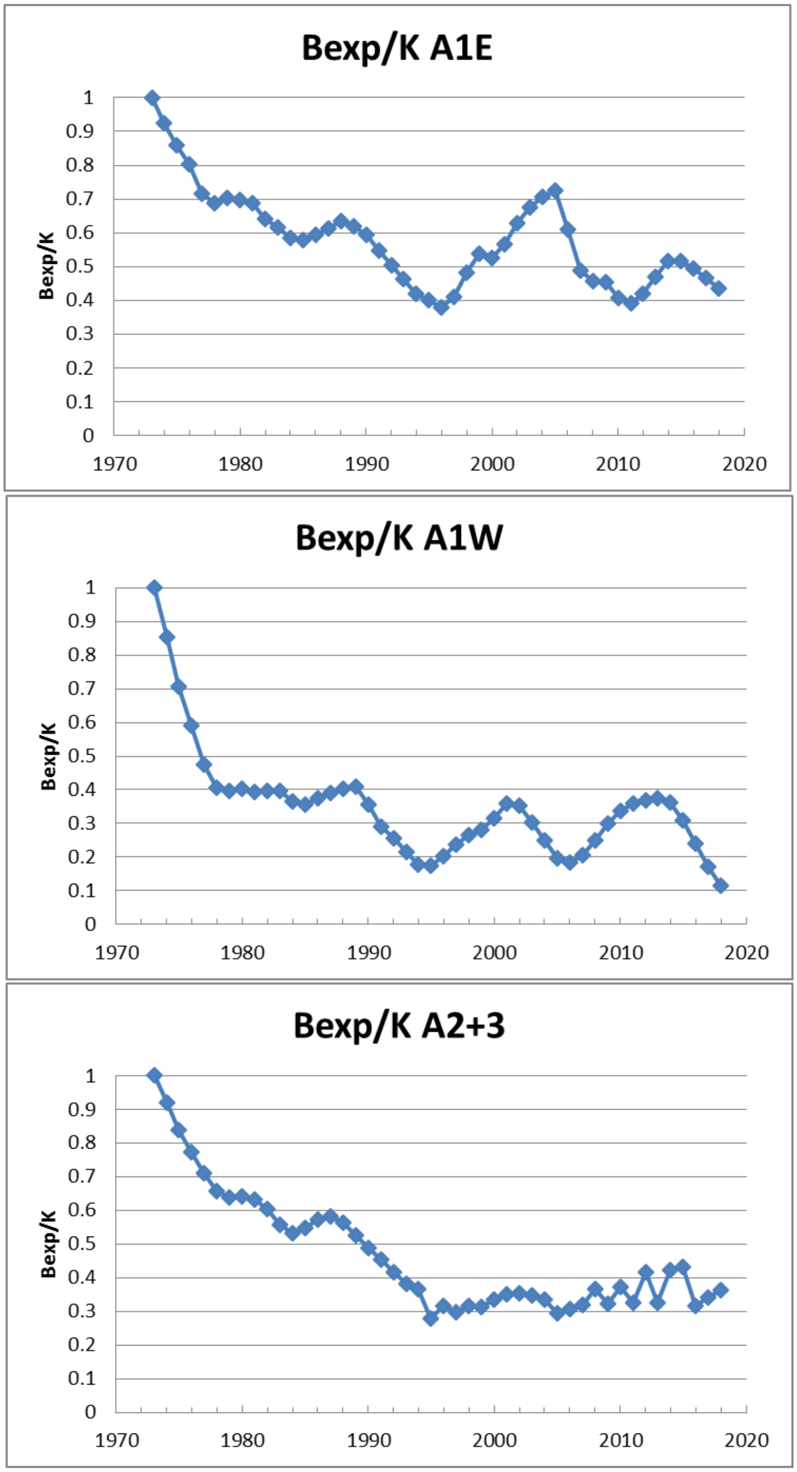


Figure 3: Model estimates of ***F*** (the harvest proportion) for the 2018 RC assessment.

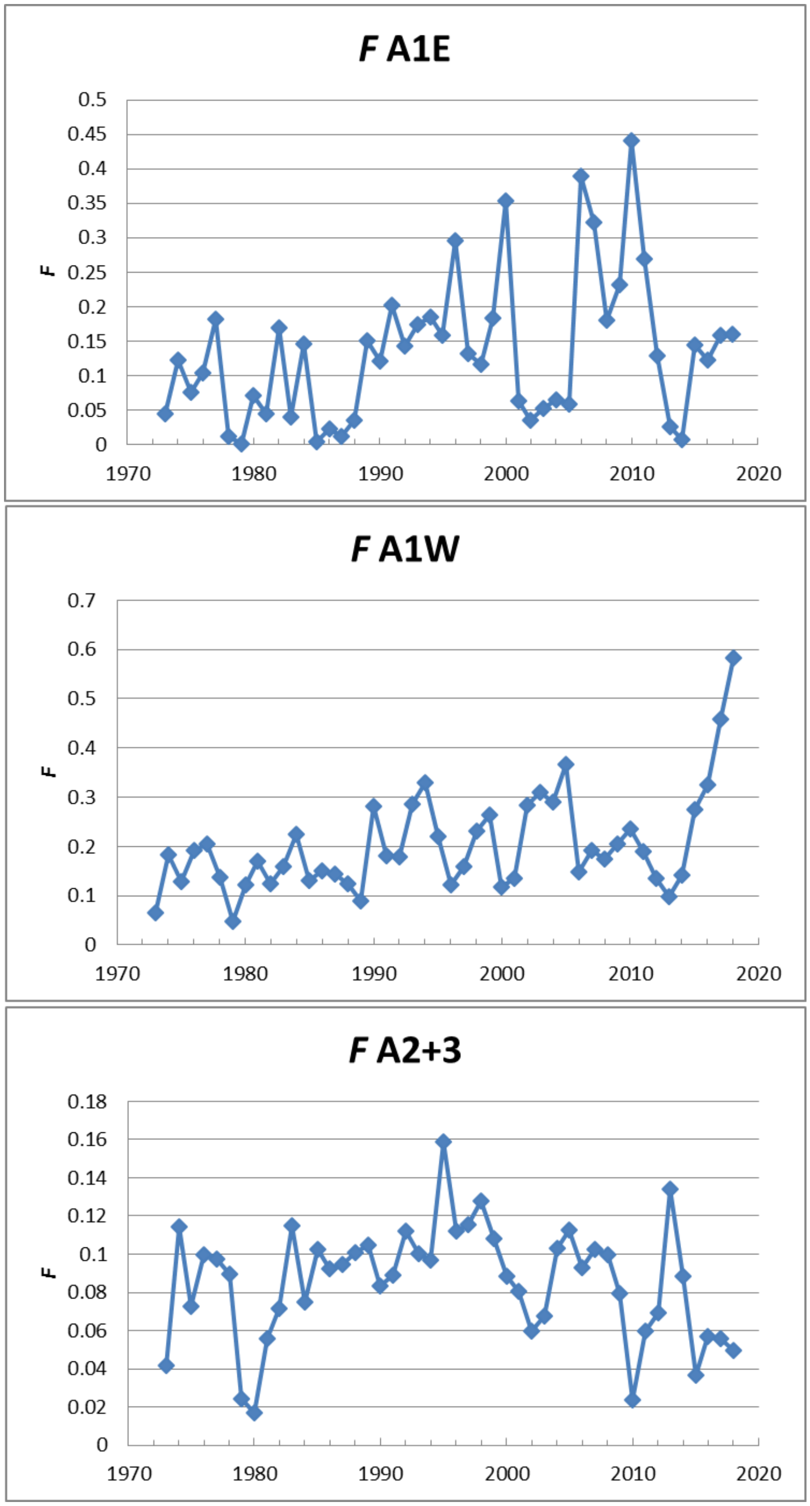


Figure 4a: The 2018 NEW RC estimated selectivity functions for A1E, A1W and A2+3 (for the 1973-1994 period). Note that the A2+3 selectivity functions vary over time for the period 1995-2015 and these are shown in Figure 4b.

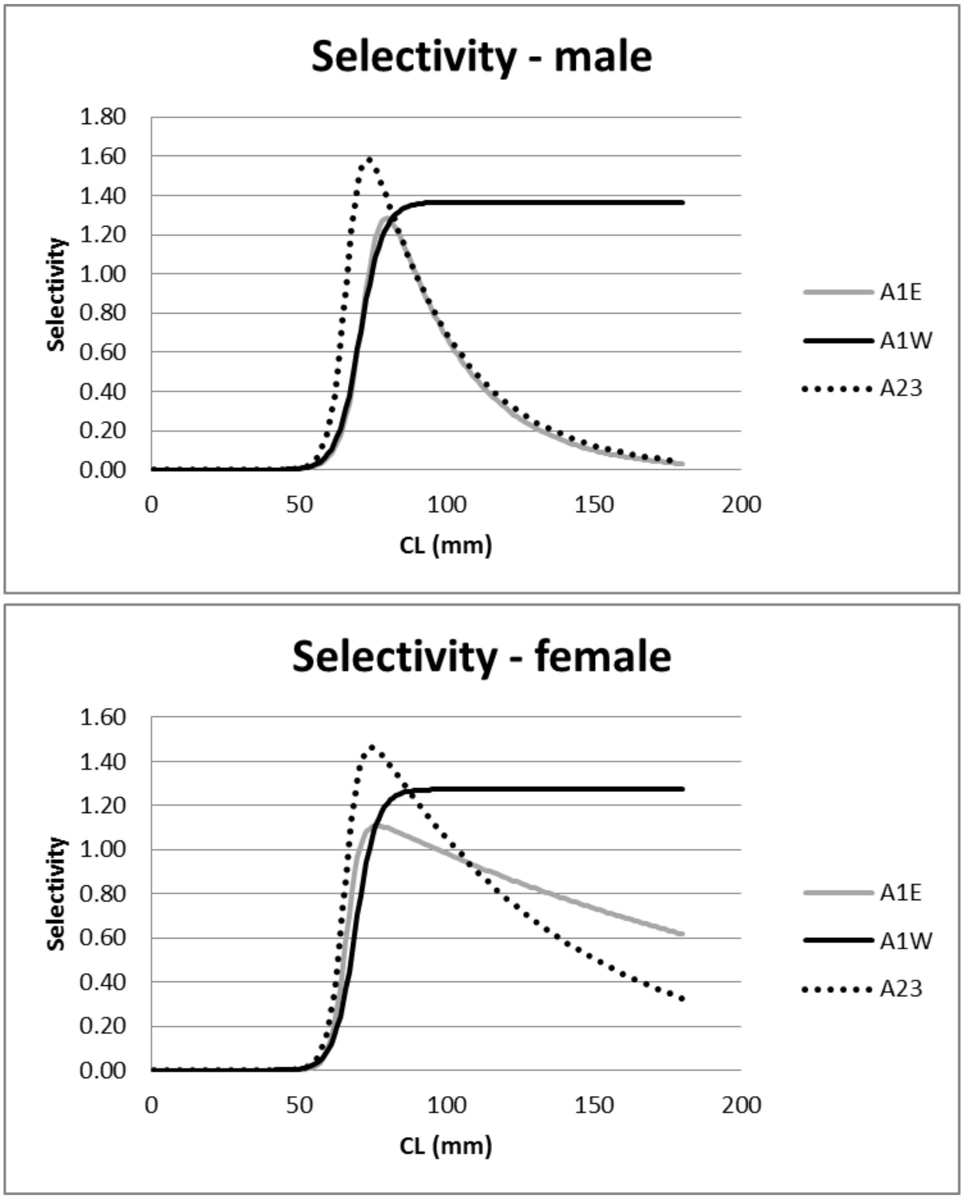
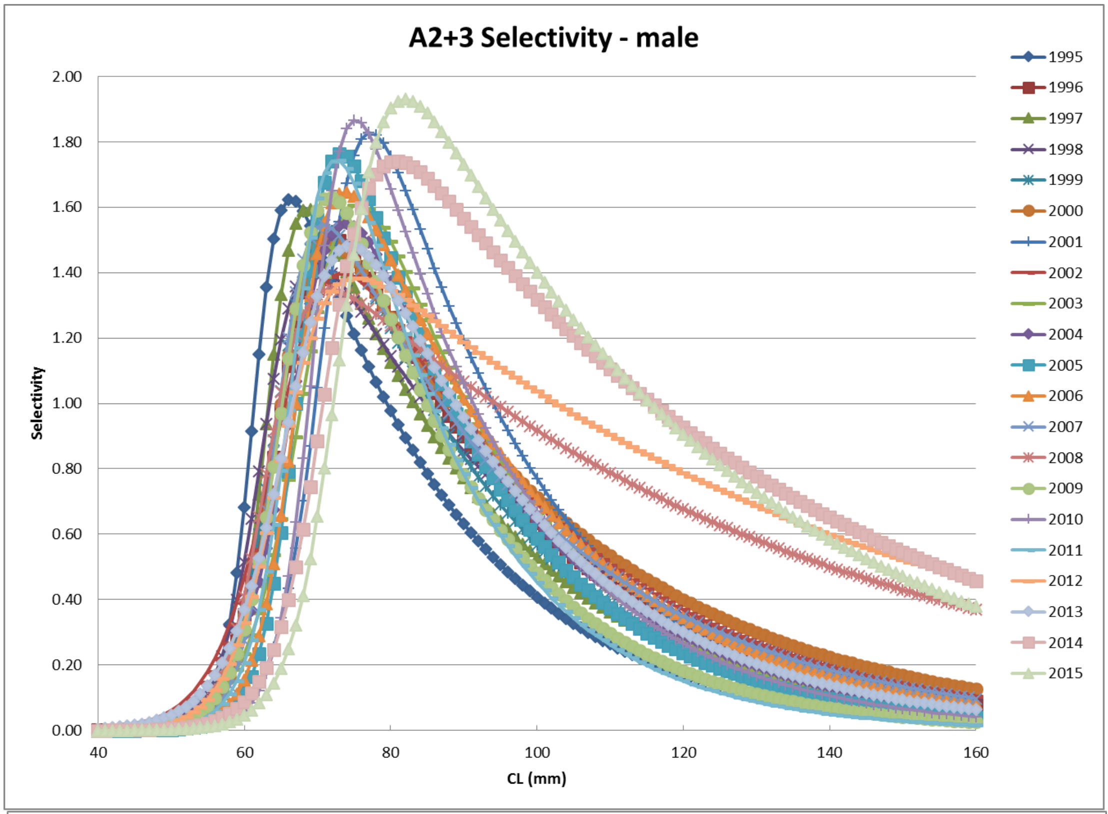


Figure 4b: The 2018 NEW RC estimated selectivity functions for A2+3 for 1995-2015.



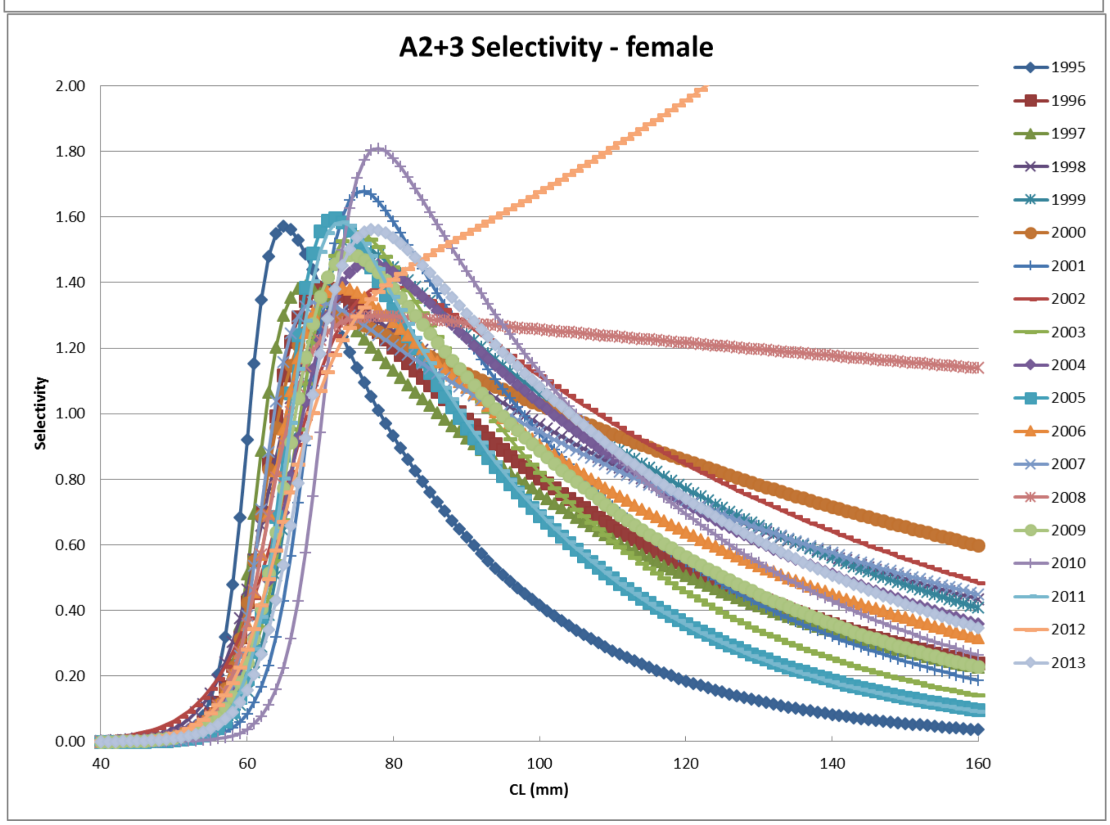


Figure 4c: Comparison of the stock-recruit residuals estimated for the 2018 NEW RC (**σ_R=0.8) and Sen3 (σ_R=0.4).**

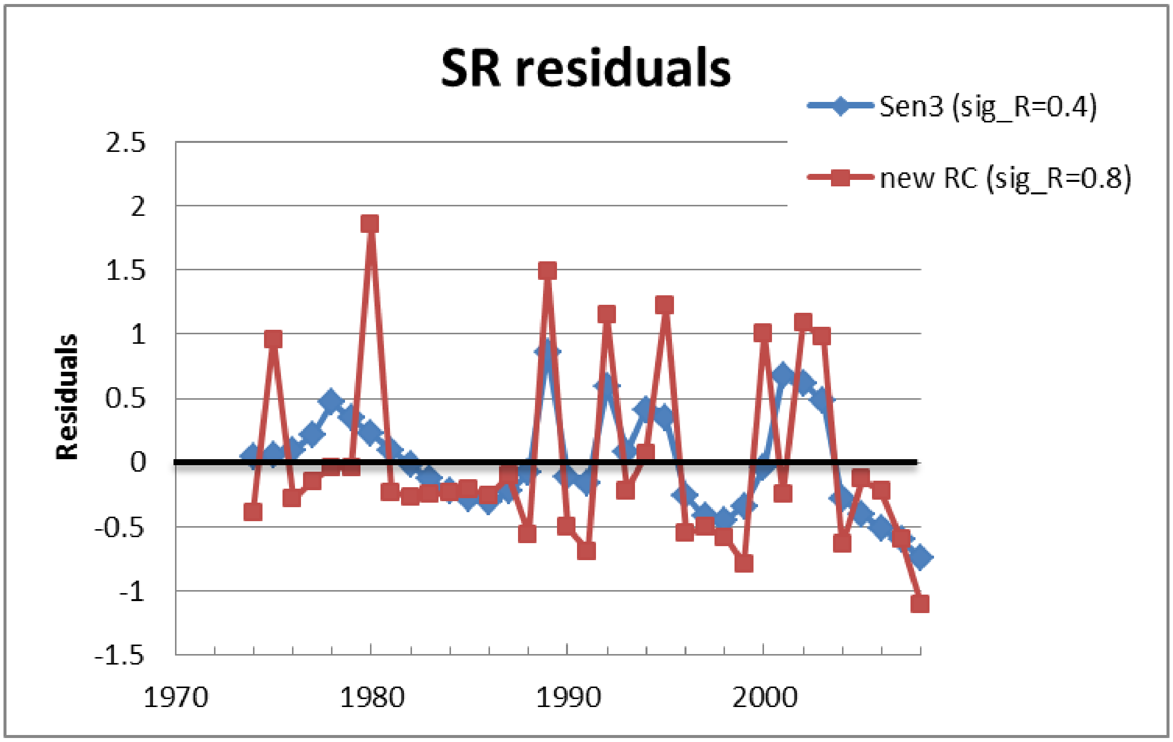


Figure 5: The 2018 NEW RC catch-at-length residuals. The dark bubbles reflect positive and the light bubbles reflect negative residuals, with the bubble radii proportional to the magnitudes of the residuals.

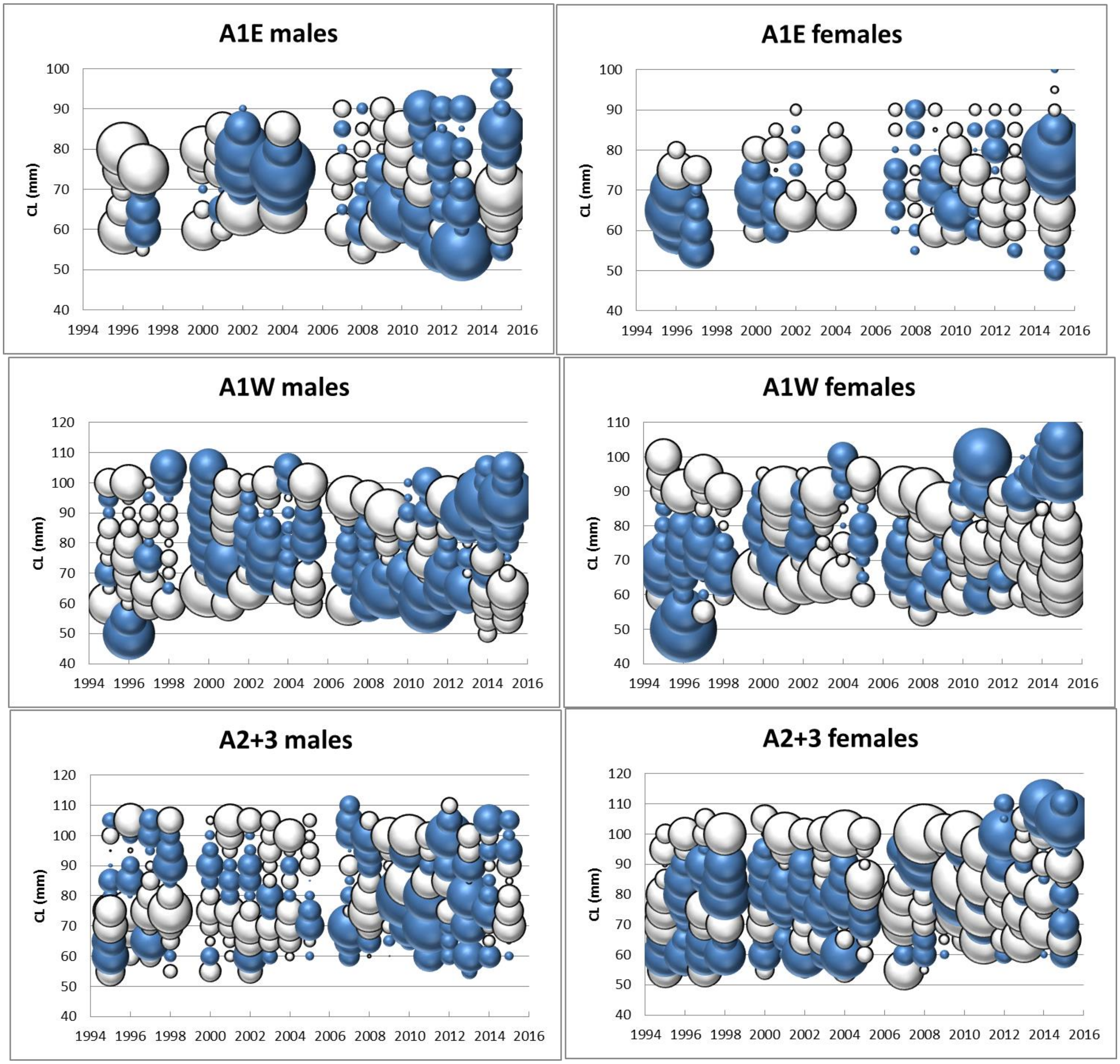


Figure 6: The sustainable yield (SY) against spawning biomass (B_{sp}) curve (top), and SY against F (bottom) as estimated for the 2018 NEW RC assessment model. The current (2019) Bsp value is also indicated on the top plot.